Study of Ion Migration During the Initiation Mechanism of Corrosion by Particle Deposition

A. Neufeld (CSIRO Australia) and H. Isaacs (BNL)

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Introduction: In the corrosion processes that take place when sodium chloride particles are placed on zinc metal, cations and anions are transported specifically because of the electrochemical reactions that are occurring at the zinc surface. Monitoring the corrosion process on zinc has been undertaken by Neufeld et. al. [1] where a Scanning Kelvin probe was used to show the potential distributions over the area which the corrosion initiation has occurred. This work has specifically highlighted the relative size and positions of the anodic and cathodic regions and the rate at which a process call "secondary spreading" occurs in the cathodic region. Secondary spreading is a process where a very thin film (ca. 10-20 microns) of alkaline electrolyte radiates outward from the edge of a hemispherical droplet. Post-initiation microprobe analysis has shown that sodium is transported through this film outward to the perimeter, however only Synchrotron studies could tell us if what the distribution of sodium ions are during process, at what rate they are transported, and what the mechanism is for the causing the final distribution of sodium.

Methods and Materials: Using a micro-syringe, a droplet of approximately 0.2 microliters was placed on the surface of polished zinc. Rubidium and bromine were used as indicators for the lighter elements sodium and chloride respectively. Zinc specimens where mounted in a Perspex chamber which was sealed using a Mylar film. The Perspex chamber was mounted on stepper motor driven translation stages and using a CCD camera, the micro-droplet was located and positioned to the focus point of the X-Ray beam with spot size 25 microns in diameter. During line scans, steps of between 25 and 50 microns were used, collecting X-Rays for between 2 and 4 seconds live time depending on the beam current.

Figure 1. Secondary spreading during a typical initiation experiment

Results: Although visible to the naked eye, the physical development of the initiation process was best observed by the aid of optics and a CCD video camera system. After approximately 10 minutes, a thin film can be seen to commence radiating outward symmetrically from the edge of the hemispherical droplet. Illustrated on the right in figure 1, is the droplet and a thin film, the result of the process called *secondary spreading*. Illustrated in figure 2 is a compilation of line scans taken from the start of the initiation until 250 minutes. The hemispherical droplet was centered at the 2mm position. As time progresses, rubidium is detected in the secondary spreading area as indicated in blue and green, and quite clearly the concentration decreases within the droplet.

Conclusions: Rubidium is transported over a number of hours outward through the thin film in the area of secondary spreading however bromine is not. This confirms that hydroxide generated from oxygen reduction is the primary counter ion for sodium and rubidium ions.

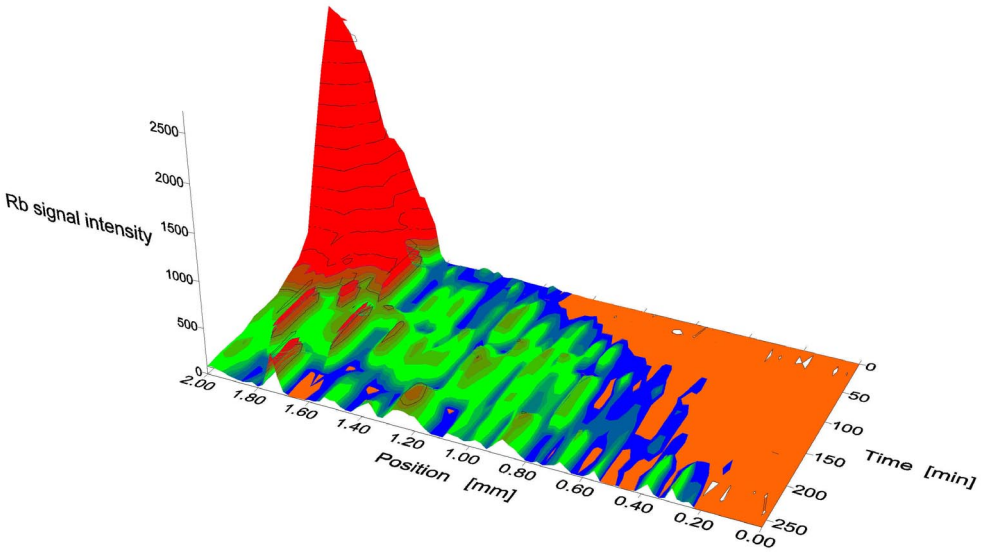

Figure 2. Secondary spreading during a typical initiation experiment

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References: [1] A. K. Neufeld, I. S. Cole, A. Bond and S. Furman, " The Initiation Mechanism of Corrosion of Zinc by Sodium Chloride Particle Deposition." Submitted to Corrosion Science (Sept. 2000)